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MULTIBAND PLANAR PRINTED MONOPOLE ANTENNA WITH DEFECTED REFLECTOR FOR WIRELESS COMMUNICATION SYSTEM

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ABSTRACT

In this paper, a multi-band planar printed monopole antenna with defected reflector for wireless communication system is presented. The antenna has been designed based on meander lines monopole printed elements and the rectangular ground structure with defected reflector above the proposed antenna. The each element of meander lines is designed with a half wavelength to radiate at a frequency of 3.6 and 5.8 GHz for Wireless Local Area Network (WLAN) application. The 50 ohm probe feed SMA type is used to feed the signal into the antenna structure. The proposed antenna is designed and simulated by using Computer Simulation Technology (CST) software. The antenna performance is analyzed in term of the return loss, bandwidth, gain, directivity, and radiation pattern at the design frequency. The bandwidth of reflection coefficient which are less than - 10 dB can be seen at (305 and 125) MHz, (248 and 359) MHz and (267 and 197) MHz for 2.4, 3.6 and 5.8 GHz for with/out defected reflector. The additional defected reflector helps to improve the return loss, bandwidth, gain and directivity.

Keywords: multi-band, monopole antenna, defected reflector.

INTRODUCTION

Now a days, wireless communication system has rapid growth nationwide. The increase of data transfer of mobile communication network requires system to operate more than one band. The Wireless Local Area Network (WLAN) is selected because it cost effective and reliable solution for high speed data transfer, that enabling the corresponder mobility. The increasing used in WLAN technology requires the system to be integrate with IEEE 802.11a, IEEE 802.11y and IEEE 802.11b (2.4 - 2.484 GHz, 3.655 - 3.695 GHz and 5.725 - 5.825 GHz) as the best solution. There are a lot of reported antenna designs for WLAN system, but most of them are single and dual - band [1-5].

The multi-band operation for WLAN system of wireless communication systems have developed widely that suitable to work in commercial, industrial and medical area. There are a ways to cover all desired frequency bands by using wideband antenna. But, affect the existing wireless or navigation systems and cause interference to systems such as 802.11a, ISM band wireless systems, mobile cellular, and GPS. To encounter this problem antenna that can be operated only on desired frequencies will be the best solution. Various designs have been reported that work for all three wireless frequency bands [6-8]. Several designs have been discovered by researcher in order to meet the needs of multiple applications in single antenna design [9-12].

Planar monopole antennas are high demand in mobile system due to the advantages of easy fabrication, simple feature and low cost [13-15]. Since the mobile communication system require to become smaller in size, the proposed antenna need to be more compact than usual. Many of compact antennas with broadband and multi-band characteristic such as monopole antenna, dipole antenna and planar configurations have been discovered [16-21]. A compact and simple multi-band antenna that covers all three desired frequency bands is preferable. Futhermore, it is need to be able to control the antenna bandwidth over different frequency bands idependently [22]. The planar monopole antennas usually have low gain and bididirectional radiational pattern. So, the proposed antennas need to be integrated with a reflector to achieve directional radiation performances [23-24].

In this paper, multi-band planar printed monopole antenna with defected reflector for wireless communication system such WLAN system has been proposed. The multi-band characterizations are achieved by using three meander branch lines. The three branches have been designed in order each line control it's the desired frequency. The defected reflector has been added on the proposed antenna in order to investigate the antenna performances. The antenna design and structure will be presented in section two. Then, the performance results that has been simulated and investigates for the proposed antenna in section three. Finally, the last chapter contains conclusion.

ANTENNA DESIGN

The propose antenna is designed on an FR4 substrate board which has a permittivity of 4.4 and dimensions of 25 mm x 14 mm x 1.6 mm. Figures 1 and 2 shows the geometry and the design structure of the proposed antenna. The antenna has been designed to mount on the rectangular ground 10x10 (L_g x W_g) mm. The ground structure is made of rectangular copper with a

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dimension of W x L x T. Then, 50 ohm SMA coaxial probe feed is used to feed the antenna through printed line, L_{A4}.

The printed elements have been designed by using a mender line technique to reduce the size of the antenna. The multi-band frequency is generated by three different radiators of the proposed antenna which are L_{A2}, L_{C1} and L_{B1}. Each radiator's length is referred from the edge of point X until the end of the respective radiator for λ/2 (half-wavelength). Table-1 shows that the further optimization process has been done to obtain the resonance frequency at 2.4 GHz, 3.6 GHz and 5.8 GHz.

Table-1. The optimized parameter dimension.

Design parameters	**Dimension** (mm)
First radiator: L_{A1}	1.3
L_{A2}	7.4
L_{A3}	4.8
L_{A4}	18.5
L_{A5}	2.4
Second radiator: L_{B1}	12
L_{B2}	1.3
Third radiator: L_{C1}	11
L_{C2}	1.3
Connector diameter: L_R	1.3
Reflector stand: H_R	10
W_R	10
Defected reflector: D_1	1.3
D_2	7.4
D_3	4.8
D_4	18.5
D_5	2.4
H_D	20
W_D	25
T_D	1.6
Reflector distance, Rg	25

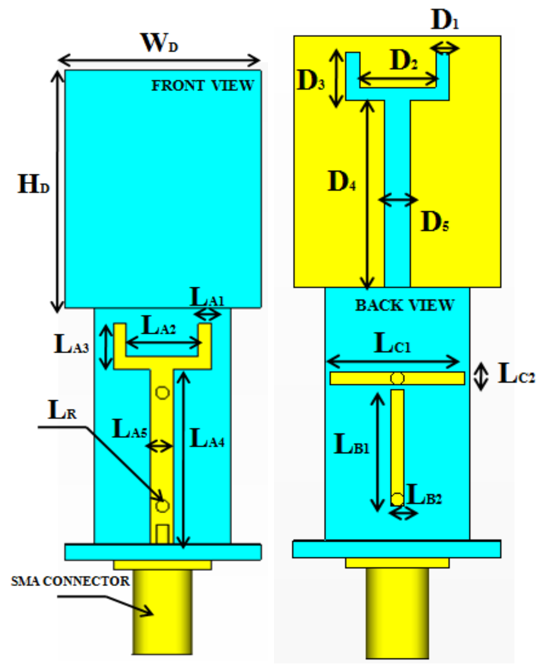

Figure-1. The optimized dimension for front and back of the proposed antenna.

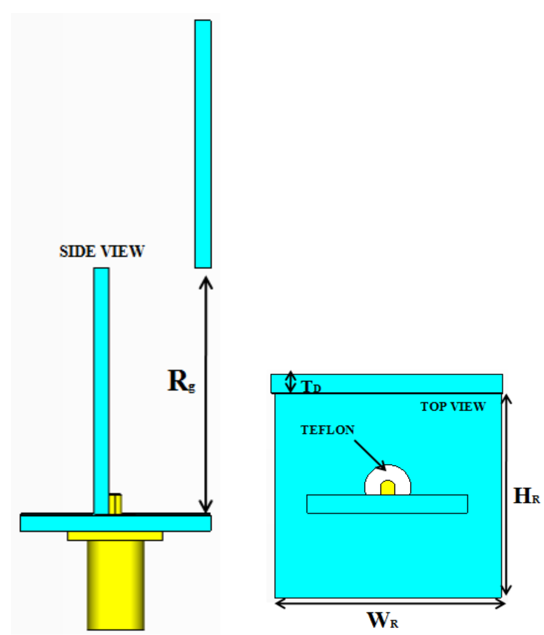

Figure-2. The optimized dimension for side and top of the proposed antenna.

RESULTS AND DISCUSSIONS

This section presents the performance results of the proposed antenna at WLAN communication system frequencies at 2.4 GHz, 3.6 GHz and 5.8 GHz. The performance results such as return loss, gain, directivity, and radiation pattern at the desired frequency is analyzed. Figure-3 shows that the parameter studies on the distance

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of defected reflector range from the edge of the proposed antenna. In order to obtain good return loss for the desired frequency, the distance of defected reflector, R_g about 25 mm has been selected.

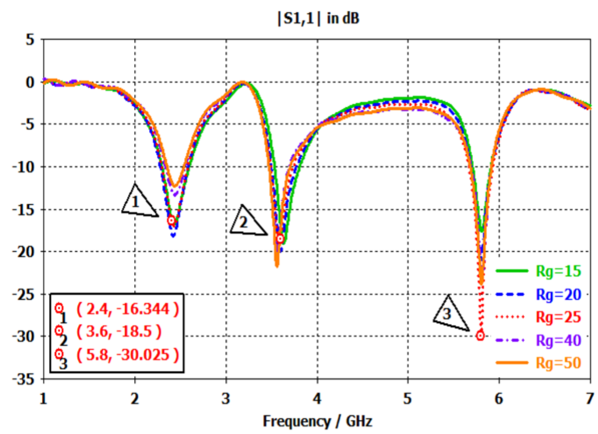

Figure-3. Parameter study on distance of defected reflector range, R_g.

Figure-4 shows the return loss of the proposed antenna for three operating frequency bands with/out defected reflector. From the result, the reflection coefficient (S11) for the first radiator at 2.4 GHz is -16.34 dB and-11.417 dB; bandwidth is about 305 MHz and 125 MHz. The second radiator can be found at a frequency of 3.6 GHz with a reflection coefficient (S11) of -18.5 dB and -22.613 dB. The return loss for a third radiator is -30.03 dB and -19.335 dB at a frequency of 5.8 GHz. The simulated bandwidth for second and third radiator is 248 MHz and 359 MHz then, 267 and 197 MHz respectively for with/out defected reflector. From the observation, additional defected reflector help the return loss improve and increase the bandwidth especially for 2.4 and 5.8 GHz. For frequency 3.6 GHz, it still remains good return loss although it decreases little after the defected reflector has been added to the proposed antenna.

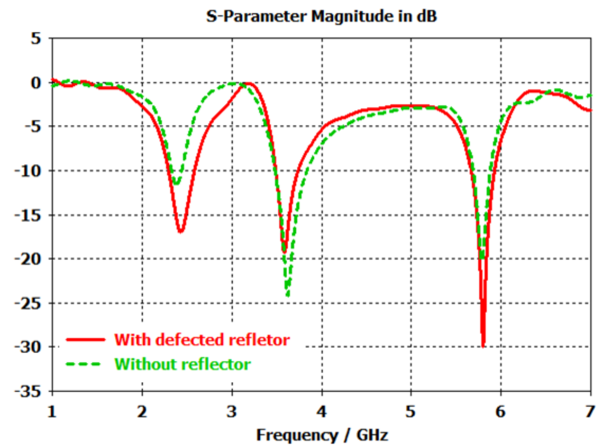

Figure-4. Reflection coefficient versus frequency of the proposed antenna with/out defected reflector.

Table-2 shows the simulated gain and directivity of the proposed antenna at 2.4 GHz, 3.6 GHz and 5.8 GHz. Both gain and directivity of the proposed antenna are increased as the desired frequency increased. The maximum gain and directivity of 4.131 dB and 4.061 dBi is found at a frequency of 3.6 GHz. It shows that the additional defected reflector helps the gain and directivity to increase.

Table-2. Gain and directivity.

Frequency (GHz)	**Gain** (dB)		**Directivity** (dBi)	
	with	**without**	**With**	**without**
2.4	2.241	1.450	2.534	1.950
3.6	4.131	2.018	4.061	2.054
5.8	3.020	2.814	3.111	3.001

Figure-5 shows the radiation pattern of the proposed antenna at 2.4 GHz, 3.6 GHz and 5.8 GHz for with/out defected reflector. The radiation patterns look like number 8 at a frequency of 2.4 GHz and 3.6 GHz. While the radiation pattern has 4 main unequal major lobes at an elevation angle of $+50^0$, -50^0, $+130^0$ and -130^0. The half power bandwidth (HPBW) for radiation pattern at 2.4 GHz is wider compared to radiation pattern at 3.6 GHz. This is due to the directivity at 3.6 GHz is more than directivity at 2.4 GHz.

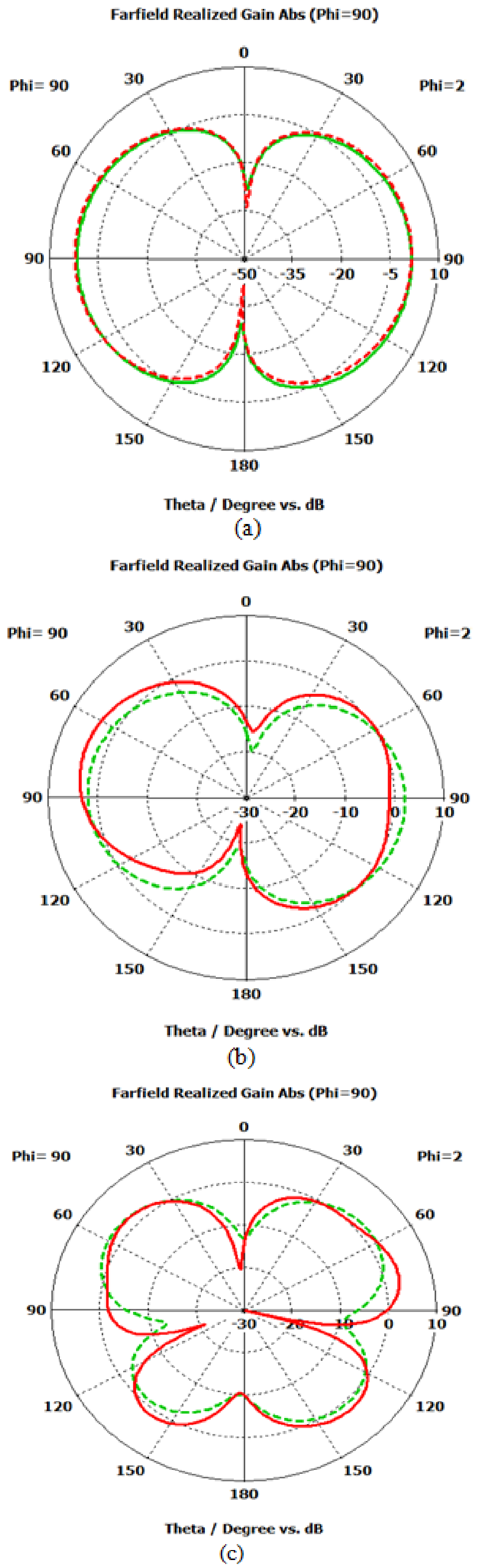

Figure-5. Radiation pattern of the proposed antenna. (a) 2.4 GHz, (b) 3.6 GHz (c) 5.8 GHz for with/out defected reflector.

CONCLUSIONS

In this paper, a multi band monopole antenna is designed and analysed to support the IEEE 802.11a, IEEE 802.11y and IEEE 802.11b (2.4 - 2.484 GHz, 3.655 - 3.695 GHz and 5.725 - 5.825 GHz). The first printed line branch is designed to resonate at 2.4 GHz. While, the second and third printed lines on the back side that connected to the front line are designed to resonate at 3.6 GHz and 5.8 GHz. It shows that the multi-band frequency is optimized about a half-wavelength of each desired frequency. The additional defected reflector helps to improve the return loss, bandwidth, gain and directivity compare to without defected reflector. The results of simulated return loss, bandwidth, gain, directivity, and radiation pattern show the antenna able to function well as designed frequencies.

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REFERENCES

Su, C. M., Chen, W. S. and Wong, K. L. 2003. Compact dual-band metal-plate antenna for 2.4/5.2-GHz WLAN operation. Mircrow. Opt. Technol. Lett. 38: 113-115.

Gao, X., Zhong, H., Zhang, Z., Feng, Z. and Iskander, M. F. 2010. Low-profile planar tripolarization antenna for WLAN communications. IEEE Trans. Antennas Wirel. Propag Lett. 9: 83-86.

Wong, K. L., Chou, L. C. and Su, C. M. 2005. Dual-band flat-plate antenna with a shorted parasicts element for laptop application. IEEE Trans. Antenna Propag. 53: 539-544.

Chang, T. N. and Jiang, J. H. 2009. Meandered T-shaped monopole antenna. IEEE Trans. Antenna Propag. 57: 3976-3978.

Nakano, H., Sato. Y., Mimaki, H. and Yamauchi, J. 2005. An inverted FL antenna for Dual-frequency operation. IEEE Trans. Antenna Propag. 53: 2417-2421.

Li, R., Pan, B., Laskar, J. and Tentzeris, M. M. 2008. A Novel low profile broadband Dual-frequency planar antenna for wireless handsets. IEEE Trans. Antenna Propag. 56: 1155-1162.

Jan, J. Y. and Tseng, L. C. 2004. Small planar monopole antenna with shorted parasitc inverted-L for wireless communication in the 2.4, 5.2 and 5.8 GHz bands. IEEE Trans. Antenna Propag. 52: 1903-1905.

Liu, W. C., Wu, C. M. and Dai, Y. 2011. Design triple frequency microstrip-fed monopole antenna using defected groun structure. IEEE Trans. Antenna Propag. 59: 2457-2463.

Yao, Y. Wang, X. and Yu, J. 2012. Multiband planar monopole antenna for LTE MIMO systems. International Journal of Antennas and Propagation.

Yang, C., Yao, Y. Yu, J. and Chen, X. 2012. Novel compact multiband MIMO antenna for mobile terminal. International Journal of Antennas and Propagation.

Zheng, Q., Yao, Y., Liu, S., Yu, J., Xie, P. and Chen, X. 2012. Tetraband small size printed strip MIMO antenna for mobile handset application. International Journal of Antennas and Propagation.

Yuang, Y., Junsheng, Y. and Xiaodong, C. 2012. Compact Multi-band Planar Antenna Design. Proceeding of APMC, Kaohsiung, Taiwan, December 4-7.

Nakano, H., Kikkawa, K., Kondo, N., Iitsuka, Y and Yamauchi, J. 2009. Low-profile equiangular spiral antenna backed by an EBG relector. IEEE Trans. Antenna Propag, 57(5): 1309-1318.

Shams, K. M. Z., Ali, M. and Hwang, H. S. 2006. A planar inductively coupled bow tie slot antenna for WLAN application. Journal of Electromagnetic Waves and Applications. 20(7): 861-871.

Dendini, T. A., Rao, Q. and Sebak, A. R. 2005. T-shaped microstrip feeding technique for a dual annular slot antenna. Journal of Electromagnetic Waves and Applications. 19(5): 605-614.

Hwang, S. H., Moon, J. I., Kwak, W. I and Park, S. O. 2004. Printed compact dual band antenna for 2.4 and 5 GHz ISM band applications. IEE Electronic Letters. 40(25): 1658-1569.

Liu, W. C. and Liu, H. J. 2006. Compact Triple band slotted monopole antenna with asymmetrical CPW grounds. IEE Electronic Letters. 42(15): 840-842.

Si, L. M. and Lv, X. 2008. CPW-fed multiband omni-directional planar microstrip antenna using composite metamaterial resonator for wireless communications. Progress in Electromagnetics Research, PIER. 83: 133-146.

Yin, X. C., Ruan, C. L., Mo, S. G., Ding C. Y. and Chu, J. H. 2008. A compact ultra-wideband microstrip antenna with multiple notches. Progress In Electromagnetics Research, PIER. 84: 321-332.

Li, J. Y. and Gan, Y. B. 2006. Multiband characteristic of open sleeve antenna. Progress In Electromagnetics Research, PIER. 58: 135-148.

Deepu, V., Rohith, K. R., Manoj J., Suma M. N., Vasudevan, K. Aanandan, C. K. and Mohanan, P. 2007. Compact uniplanar antenna for WLAN applications. IEE Electronic Letters. 43(2): 70-72.

Mehdipour, A., Sebak, A. R., Trueman, C. W. and Denidni, T. A. 2009. Compact multiband planar antenna for 2.4/3.5/5.2/5.8 GHz Wireless Application. In Proc. IEEE AP-S Int. Symp.

Kim, Y., Yang, F. and Elsherbeni, A. Z. 2007. Compact Artificial magnetic conductor designs using planar square spiral geometries. Progress In Electromagnetics Research. 77: 43-54.

Gu, Y. Y., Zhang, W. X. and Ge, Z. C. 2007. Two improved Fabry-Perot resonator printed antennas using EBG superstrate and AMC substrate, Journal Electromagnetic Waves and Applications. 21(6): 719-728.